Table 13-11

ESTIMATED COST - ALTERNATIVE 3: SOUTH PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST								
Groundwater Extraction								
Extraction Wells	4,400	ea	$60	$140	$200	$264,000	$616,000	$880,000
Extraction Pumps	4	ea	46,000	9,000	55,000	184,000	36,000	220,000
Pipeline	14,400	lf	50	58	108	720,000	835,200	1,555,200
Subtotal								$2,435,200
Treatment Facilities								
Temporary Filters	5	ea	$10,000	$1,200	$11,200	$50,000	$6,000	$56,000
Strippers,Controls,Blowers	3	ea	162,500	52,100	214,600	487,500	156,300	643,800
Effluent Tank	1	ea	70,000	30,500	100,500	70,000	30,500	100,500
GAC Units	3	ea	70,000	8,500	78,500	210,000	25,500	235,500
Chlorination System	1	ls	43,000	7,000	50,000	43,000	7,000	50,000
pH Control System	1	ls	43,000	7,000	50,000	43,000	7,000	50,000
Building	1,250	sf	50	20	70	62,500	25,000	87,500
Structural	1	ls			103,580			103,580
Site Work & Yard Piping		ls			132,688			132,688
Site Electrical		ls			140,250			140,250
Subtotal								$1,599,818

Table 13-11 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 3: SOUTH PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST (Cont'd.)								
End Use								
Booster Pumps	4	ea	$68,800	$34,000	$102,800	$275,200	$136,000	$411,200
Subtotal								$411,200
Groundwater Monitoring Wells								
Wells	4,800	lf	$40	$95	$135	$192,000	$456,000	$648,000
Well Head Completion	4	ea	6,000	3,000	9,000	24,000	12,000	36,000
Subtotal								$684,000
TOTAL CONSTRUCTION COST								$5,130,218
Contractor OH & P		15%						$769,533
Engineering & Const. Management		15%						769,533
Administration		5%						256,511
Contingency		20%						1,026,044
TOTAL CAPITAL COST								$7,951,839

Table 13-11 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 3: SOUTH PLANT

Description	Utilities	Materials	Labor	Total
ANNUAL O&M COST				
Groundwater Extraction				
Extraction Wells	$282,500	$4,875	$34,500	$321,875
Pipeline	0	20,000	9,360	29,360
Subtotal				$351,235
CAPITAL COST (Cont'd.)				
Treatment Facilities				
Strippers,Controls,Blowers	$212,300	$11,900	$70,200	$294,400
GAC Units	0	70,000	14,040	84,040
Chlorination System	2,270	9,720	18,000	29,990
pH System	6,880	38,880	18,000	63,760
Subtotal				$472,190
End Use				
Booster Pumps	$470,850	$3,400	$33,840	$508,090
Subtotal				$508,090
Groundwater Monitoring				
Monitoring Wells	$0	$6,500	$149,500	$156,000
Subtotal				$156,000
TOTAL ANNUAL O&M COST				$1,487,515
PRESENT WORTH OF ANNUAL O&M COST				$22,866,751
TOTAL PRESENT WORTH				$30,818,590

Table 13-12

ESTIMATED COST - ALTERNATIVE 3: NORTH PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST								
Groundwater Extraction								
Extraction Wells	500	lf	$60	$140	$200	$30,000	$70,000	$100,000
Extraction Pumps	1	ea	36,000	9,000	45,000	36,000	9,000	45,000
Pipeline	2,500	lf	36	44	80	90,000	110,000	200,000
Subtotal								$345,000
Treatment Facilities								
Temporary Filters	3	ea	$10,000	$1,200	$11,200	$30,000	$3,600	$33,600
Strippers,Controls,Blowers	2	ea	160,000	52,100	$212,100	320,000	104,200	424,200
Effluent Tank	1	ea	51,300	24,700	76,000	51,300	24,700	76,000
GAC Units	2	ea	70,000	8,500	78,500	140,000	17,000	157,000
Chlorination System	1	ls	30,700	5,000	35,700	30,700	5,000	35,700
pH Control System	1	ls	30,700	5,000	35,700	30,700	5,000	35,700
Building	1,080	sf	50	20	70	54,000	21,600	75,600
Structural	1	ls			69,080			69,080
Site Work & Yard Piping		ls			90,688			90,688
Site Electrical		ls			85,536			85,536
Subtotal								$1,083,104

Table 13-12 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 3: NORTH PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST (Cont.)								
End Use								
Booster Pumps	3	ea	$68,800	$34,000	$102,800	$206,400	$102,000	$308,400
Subtotal								$308,400
G/W Monitoring Wells								
Wells	1,800	lf	$35	$80	$115	$63,000	$144,000	$207,000
Well Head Completion	3	ea	6,000	3,000	9,000	18,000	9,000	27,000
Subtotal								$234,000
TOTAL CONSTRUCTION COST								$1,970,504
Contractor OH & P		15%						295,576
Engr. & Const. Management		15%						295,576
Administration		5%						98,525
Contingency		20%						394,101
TOTAL CAPITAL COST								$3,054,282

Table 13-12 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 3: NORTH PLANT

Description	Utilities	Materials	Labor	Total
ANNUAL O&M COST				
Groundwater Extraction				
Extraction Wells	$329,600	$2,400	$18,000	$350,000
Pipeline		2,500	1,800	4,300
Subtotal				$354,300
Treatment Facilities				
Strippers,Controls,Blowers	$106,150	$8,925	$52,650	$167,725
GAC Units		35,000	12,690	47,690
Chlorination System	1,470	6,220	16,000	23,690
pH System	4,410	24,880	16,000	45,290
Subtotal				$284,395
End Use				
Booster Pumps	$235,400	$1,880	$28,300	$265,580
Subtotal				265,580
Groundwater Monitoring		500	7,500	8,000
Subtotal				8,000
TOTAL ANNUAL O&M COST				912,275
PRESENT WORTH OF O&M COST				$14,023,903
TOTAL PRESENT WORTH				$17,078,185

Groundwater Extraction

The groundwater extraction process is the same as in Alternative 2 and consists of four 2,000 gpm wells ahead of the plume and one new 800 gpm well in the Newmark Wellfield. Water collection, transmission systems, and the proposed treatment plant site are also the same as Alternative 2.

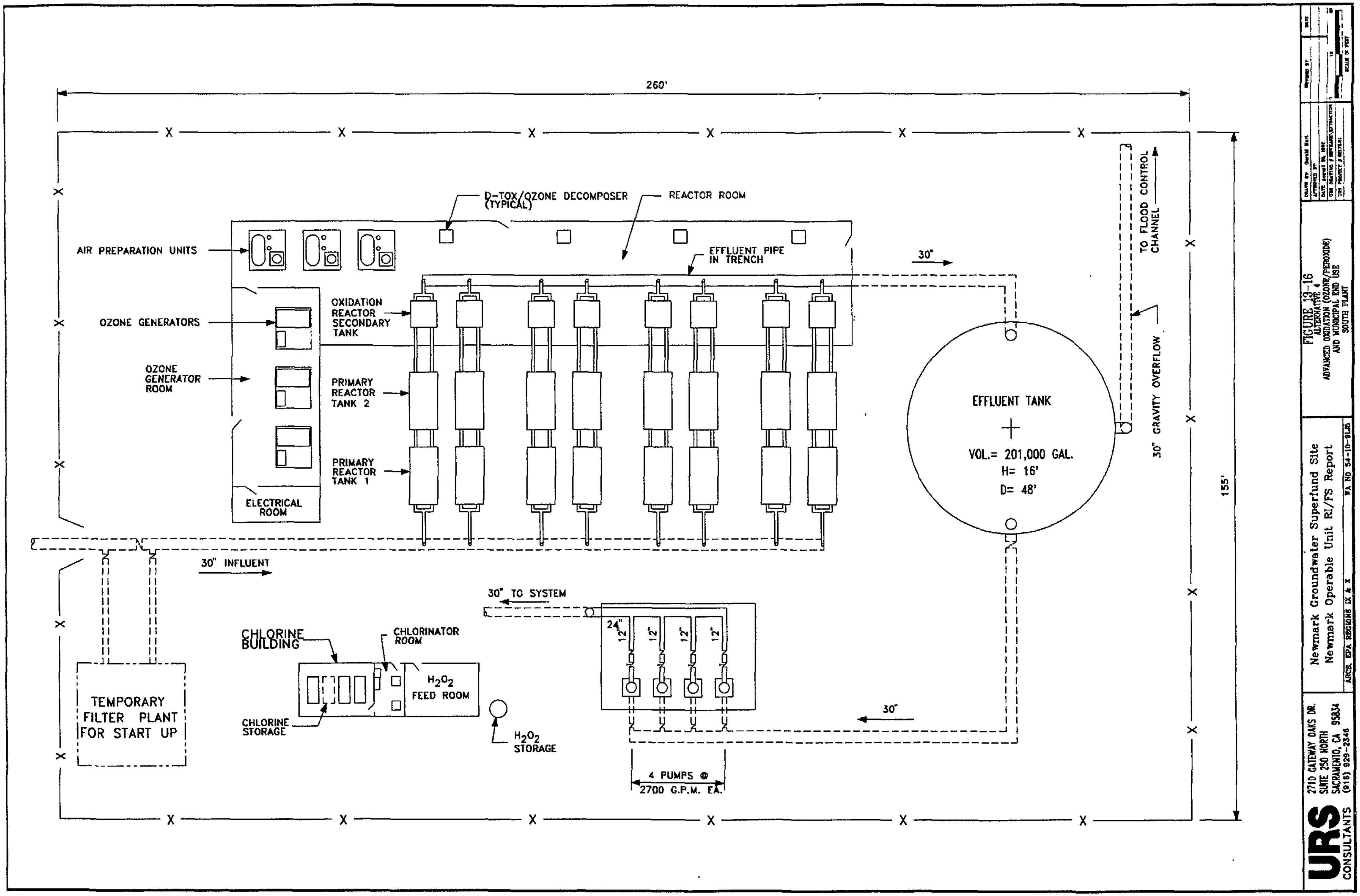
Treatment System

The proposed South Treatment Plant is shown on Figure 13-16 and the North Treatment Plant is shown on Figure 13-17.

Advanced Oxidation Treatment. The treatment process is arranged to treat and dose individual 1,000 gpm flow streams in parallel. Table 13-13 presents specific plant information. Individual 1,000 gpm streams were selected because of existing experience in treating PCE for this flow rate. The operation is the same for each treatment stream. Each stream uses two 5,000 gallon concrete primary reaction tanks (Reactor Tanks 1 and 2) operating in series. Hydrogen Peroxide is injected into the header ahead of Tank 1 and ozone is injected into both primary tanks. Preliminary oxidation of organics occurs in the primary tanks. The secondary Oxidation Reactor tank is contained within a building and is used for removing ozone and peroxide from the water as well as a final polish for the removal of organic residuals.

Off-gas from the secondary tank is treated by a standard catalytic ozone decomposer to remove any residual ozone and TCE or PCE vapors present in the vapor stream. The TCE and PCE are oxidized to Cl^-, CO_2, and H_2O. The ozone is decomposed to oxygen. System operation is monitored and shut-down functions are automated in the case of either the water flow stopping, overheating of the electrical enclosures, or an interruption of the chemical feed systems.

Three ozone generators were selected to supply two percent by weight ozone to both the primary and secondary tanks. Two generators will normally supply the required ozone dosage. The third generator will function as a backup unit. Three air preparation units consisting of an air compressor, heatless absorption dryers, filters and coalesces are also a part of the system. Like the ozone generator system, two will operate normally to supply air to the generators and the third will function as a backup unit.


260'
155'
D-TOX/OZONE DECOMPOSER (TYPICAL)
REACTOR ROOM
AIR PREPARATION UNITS
EFFLUENT PIPE IN TRENCH
30"
TO FLOOD CONTROL CHANNEL
OZONE GENERATORS
OXIDATION REACTOR SECONDARY TANK
OZONE GENERATOR ROOM
PRIMARY REACTOR TANK 2
PRIMARY REACTOR TANK 1
ELECTRICAL ROOM
EFFLUENT TANK
VOL.= 201,000 GAL.
H= 16'
D= 48'
30" GRAVITY OVERFLOW
30" INFLUENT
30" TO SYSTEM
24"
12"
12"
12"
12"
CHLORINE BUILDING
CHLORINATOR ROOM
H_2O_2 FEED ROOM
CHLORINE STORAGE
H_2O_2 STORAGE
TEMPORARY FILTER PLANT FOR START UP
30"
4 PUMPS @ 2700 G.P.M. EA.
FIGURE 13-16
ALTERNATIVE 4
ADVANCED OXIDATION (OZONE/PEROXIDE) AND MUNICIPAL END USE
SOUTH PLANT
Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report
URS CONSULTANTS
2710 GATEWAY OAKS DR.
SUITE 250 NORTH
SACRAMENTO, CA 95834
(916) 929-2346

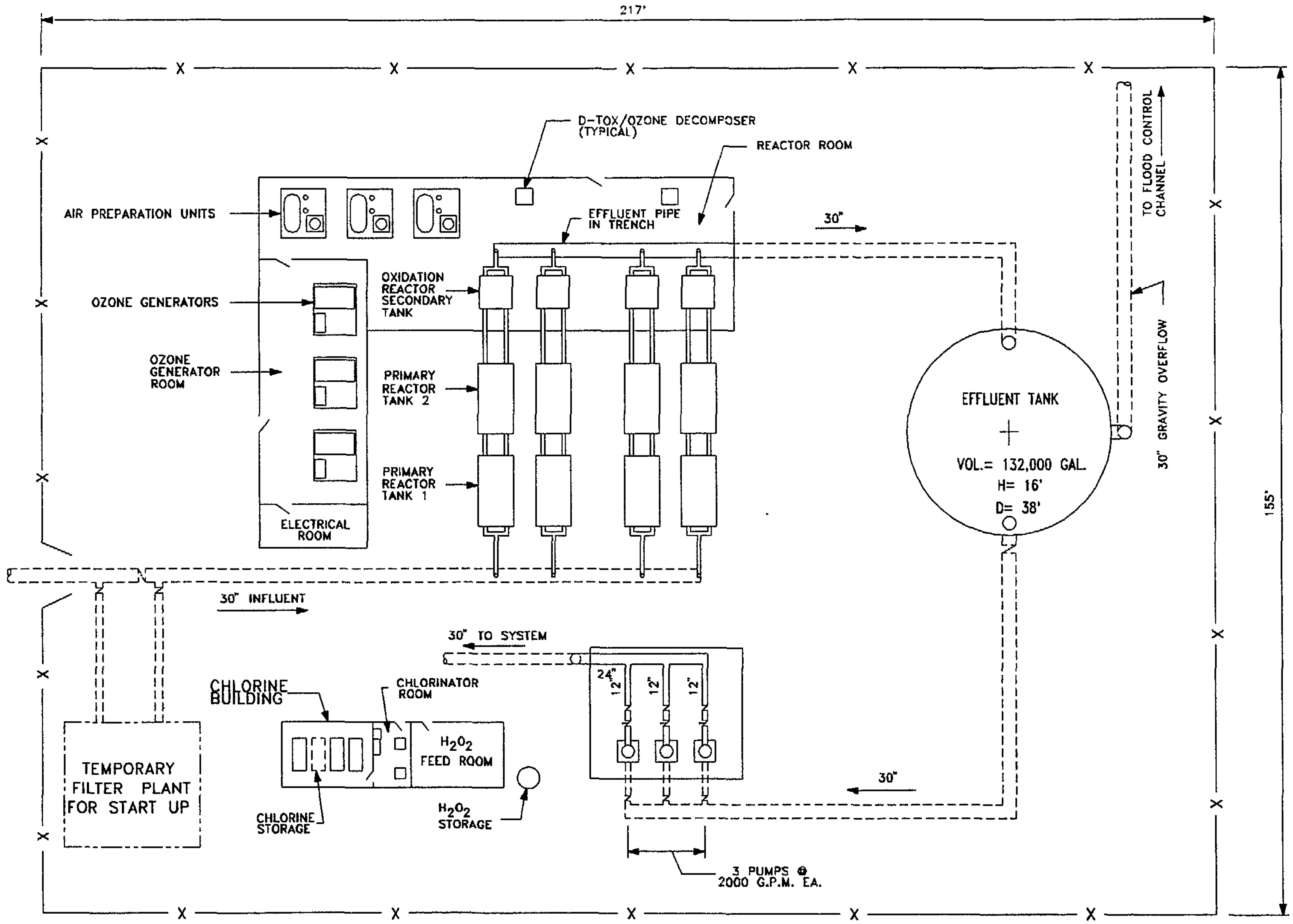


FIGURE 13-17
ALTERNATIVE 4
ADVANCED OXIDATION (OZONE/PEROXIDE) AND MUNICIPAL END USE
NORTH PLANT

Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report

ARCS, EPA REGIONS IX & X — WA NO 54-10-9LJ5

URS CONSULTANTS
2710 GATEWAY OAKS DR.
SUITE 250 NORTH
SACRAMENTO, CA 95834
(916) 929-2346

Table 13-13

DESIGN CRITERIA
ALTERNATIVE 4

Item	Units	South Plant	North Plant
<u>GROUNDWATER EXTRACTION SYSTEM</u>			
1. Extraction Wells			4 existing
Number	each	4	1 additional
Capacity (each)	gpm	2,000	800
Total Capacity	gpm	8,000	4,000
Estimated Well Depth	ft	1,100	500
Approximate Depth to Groundwater	ft	100	230
Casing Diameter	inch	20	16
Total Pumping Head	ft	152	350
2. Raw Water Transmission System			
30-inch Diameter	L.F.	12,000	--
24-inch Diameter	L.F.	1,200	--
16-inch Diameter	L.F.	1,200	--
12-inch Diameter	L.F.	--	2,500
<u>TREATMENT SYSTEM</u>			
1. Plant Capacity	gpm	8,000	4,000
	MGD	11.5	5.8
Effluent Concentration			
Tetrachloroethylene (PCE)	μg/L	75	75
Trichloroethylene (TCE)	μg/L	10	10
Effluent Concentration			
Tetrachloroethylene (PCE)	μg/L	2	2
Trichloroethylene (TCE)	μg/L	2	2
Number of Treatment Streams	each	8	4
Operation	--	parallel	parallel
Flow Rate (each)	gpm	1,000	1,000
Flow Rate (one stream offline)	gpm	1,150	1,330
Primary Tank Capacity (Tanks 1 and 2)	gal	10,000	10,000
Secondary Tank Capacity	gal	1,300	1,300
Retention Time	min	8.7	8.7
Actual Contact Retention	min	3.1	3.1

Table 13-13 (Cont'd.)

DESIGN CRITERIA
ALTERNATIVE 4

Item	Units	South Plant	North Plant
2. Ozone System			
Design Dosage Rate	mg/L	13	13
	lb/day	1,249	624
Ozone Generator			
Number (with 1 backup)	each	3	3
Generation Capacity (each - 2% air)	lb/day	750	400
Total Generating Capacity (2% air)	lb/day	225	1,200
Dosage (max)	mg/L	23.4	25.0
Dosage (1 unit offline)	mg/L	15.6	16.7
Air Preparation Unit			
Number (with 1 backup)	each	3	3
Capacity (each)	cfm	349	186
3. Hydrogen Peroxide System			
Design Dosage	mg/L	6	6
	lb/day	576	288
Dosage (100% solution)	gal/hr	2.88	1.44
30-Day Supply	gal	2,080	1,040
H_2O_2 Pumps	each	3	3
H_2O_2 Pump Capacity	gal/hr	3	2
Maximum Dosage	mg/L	18.4	25
H_2O_2 Storage Tank	gal	3,000	1,500
4. Effluent Tank			
Working Capacity	gal (1,000)	201	132
Size (Diameter x Height)	ft	48 x 16	38 x 16
Seismic Construction	--	anchored	anchored
5. Disinfection			
Type: Gaseous Chlorine			
Dosage Rate	mg/L	0.3 - 0.5	0.3 - 0.5
	lb/day	29 - 48	14 - 29
Residual	mg/L	0.3 - 0.5	0.3 - 0.5
Unit Size	lb/day	100	50
Control	--	continuous	continuous
Storage Cylinder Size	lb	2,000	150
Number of Cylinders	each	4	8
6. Start Up Filtration			
Type: Bag Filters			
Number of Vessels	each	5	3
Flow per Vessel	gpm	2,000	2,000
Bags per Vessel	each	10	10

Table 13-13 (Cont'd.)

DESIGN CRITERIA
ALTERNATIVE 4

Item	Units	South Plant	North Plant
FINAL USE			
1. Municipal System			
Pumps: Vertical Turbine			
Number	each	4	3
Total Pumping Rate	gpm	8,000	4,000
Pump Rate (each)	gpm	2,700	2,000

The peroxide feed system consists of three standard chemical feed pumps. Two pumps would normally be operating and one would be provided for backup. Peroxide would be withdrawn from a tank on the site sized to provide storage capacity in excess of the normal 30 day requirement.

The advanced oxidation technology has been demonstrated in the EPA's Superfund Innovative Technology Evaluation (SITE) program to be capable of oxidizing both PCE and TCE. The experience is however limited to smaller flow rates (200 gpm). Newmark would require both bench and pilot scale programs prior to commitment to full scale design.

Effluent System. The effluent system operates the same as for Alternative 2. Water from the secondary tanks discharges into a common header that conveys the water to the effluent tank. The effluent tank serves as a clearwell and forebay for the municipal pump station.

Disinfection. The disinfection system operates the same as for Alternative 2. However since ozone and peroxide have been added to the water as a part of the treatment process, the chlorine dosage rate would be somewhat less than for the other alternatives.

Start-Up Filtration. The operation of the pre-filtration plant would be the same as Alternative 2. The bag filters would operate during plant start-up and well development.

End Use

The end use of the water is the same as Alternative 2. Water would be supplied to the municipal pump station.

Groundwater Monitoring Wells

The groundwater monitoring wells in this alternative are the same as those discussed in Alternative 2. Four monitoring wells would be installed downgradient of extraction wells in the plume front area. The depth of these wells is 1,200 feet. Also, three additional monitoring wells with a depth of 600 feet would be installed downgradient of Newmark Wellfield.

Overall Protection of Human Health and the Environment - The advanced oxidation with municipal disposal alternative would protect human health and the environment.

This alternative eliminates contaminants from groundwater by destruction during the oxidation process. Similar to Alternatives 2 and 3, this eliminates the risks posed to human health and the environment. Municipal supply disposal increases protection by reducing contamination levels to drinking water standards.

Compliance with ARARs - The advanced oxidation with municipal disposal alternative would meet required ARARs, if shown that it can be implemented through bench and pilot studies. Other similar advanced oxidation systems are operating and suggest that VOCs can be removed to MCLs.

Long-term Effectiveness and Permanence - This alternative is expected to provide a high degree of long-term effectiveness and permanence, similar to Alternatives 2 and 3.

If implemented, the magnitude of residual risk is expected to be low because groundwater contaminants are extracted and destroyed. The only residual remaining after remediation would be VOCs adsorbed to organic carbon in the soil. The adequacy and reliability of advanced oxidation is expected to be high but would be determined during treatability studies. The system could require replacement with a GAC system if operating costs became too high.

Reduction of Toxicity, Mobility, or Volume - The advanced oxidation with municipal disposal alternative would provide appropriate reduction of contaminant toxicity, mobility, and volume.

This alternative permanently and irreversibly reduces contaminant toxicity, mobility, and volume through oxidation. Similar to Alternatives 2 and 3, this alternative is expected to reduce levels of contamination to meet Remedial Action Objectives. It is unlikely that treatment would reverse or that residuals would result from the treatment. It is unknown at this time the amount of treated groundwater that will result from this alternative.

Short-Term Effectiveness - The advanced oxidation with municipal disposal alternative would provide short-term effectiveness.

Similar to the discussion of Alternatives 2 and 3, significant health threats to area residents or the environment are not expected during construction and implementation of this alternative. Oxidant handling and ozone generation would increase risks that are not present with either Alternatives 2 and 3, but advanced oxidation does not require carbon regeneration. Personnel responsible for oxidant handling would need to be properly protected (via personal protection equipment) against dermal contact and inhalation.

Implementability - Technically, advanced oxidation is an innovative remedial approach that is undemonstrated for expected flow rates at Newmark. Similar systems (such as the City of Southgate plant) are operating and suggest that advanced oxidation can be implemented.

During construction and operation, significant technical unknowns are not expected, other than standard details associated with a large construction project.

The alternative would require specialized personnel trained to operate and maintain the system during implementation. Additional remedial actions are not expected to be difficult to implement, and monitoring the alternative is considered to be easily accomplished at the extraction wells and oxidation unit.

Administratively, permits for on-site treatment and approval for treated water disposal into the municipal supply are required and are expected to be easily obtained.

Availability of necessary equipment and personnel is expected to be high.

Cost - Table 13-14 presents the costs associated with the South Plant and Table 13-15 presents the North Plant costs. The total project cost for this alternative is obtained by adding the cost of North and South Plants. The total project cost for Alternative 4 (capital cost - approximately $16.8 million, annual O&M cost - approximately $2.9 million and total present worth - approximately $61.0 million) is presented in Table 13-5.

Table 13-14

ESTIMATED COST - ALTERNATIVE 4: SOUTH PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST								
Groundwater Extraction								
Extraction Wells	4,400	lf	$60	$140	$200	$264,000	$616,000	$880,000
Extraction Pumps	4	ea	46,000	9,000	55,000	184,000	36,000	220,000
Pipeline	14,400	lf	50	58	108	720,000	835,200	1,555,200
Subtotal								2,435,200
Treatment Facilities								
Temporary Filters	5	ea	$10,000	$1,200	$11,200	$50,000	$6,000	$56,000
Ozone Generators	3	ea	530,000	47,500	577,500	1,590,000	142,500	1,732,500
Air Preparation Units	3	ea	97,500	11,000	108,500	292,500	33,000	325,500
Off-gas Destruction Units	4	ea	12,500	3,500	16,000	50,000	14,000	64,000
Peroxide Feed System	1	ls	55,000	12,000	67,000	55,000	12,000	67,000
Treatment Tankage	1	ls	264,000	90,000	354,000	264,000	90,000	354,000
Effluent Tank	1	ls	70,000	30,500	100,500	70,000	30,500	100,500
Chlorination System	1	ls	43,000	7,000	50,000	43,000	7,000	50,000
Building	5,250	sf	50	20	70	262,500	105,000	367,500
Controls & Instrumentation	1	ls	74,270	31,830	106,100	74,270	31,830	106,100
Structural	1	ls			68,175			68,175
Site Work & Yard Piping		ls			329,128			329,128

Table 13-14 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 4: SOUTH PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST (Cont'd.)								
Site Electrical		ls			327,393			327,393
Subtotal								$3,947,796
End Use								
Booster Pumps	4	ea	$68,800	$34,000	$102,800	$275,200	$136,000	$411,200
Subtotal								$411,200
Groundwater Monitoring Wells								
Wells	4,800	ea	$40	$95	$135	$192,000	$456,000	$648,000
Well Head Completion	4	ea	6,000	3,000	9,000	24,000	12,000	36,000
Subtotal								$684,000
TOTAL CONSTRUCTION COST								$7,478,196
Contractor OH & P		15%						$1,121,729
Engineering & Const. Management		15%						1,121,729
Administration		5%						373,910
Contingency		20%						1,495,639
TOTAL CAPITAL COST								11,591,203

Table 13-14 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 4: SOUTH PLANT

Description		Utilities	Materials	Labor	Total
ANNUAL O&M COST					
Groundwater Extraction					
Extraction Wells	$282,500	$4,875	$34,500		$321,875
Pipeline	0	20,000	9,360		29,360
Subtotal					$351,235
Treatment Facilities					
Ozone Generation	$501,500	$27,020	$77,700		$606,220
Peroxide System	9,080	147,200	18,000		174,280
Chlorination System	2,270	9,720	18,000		29,990
Subtotal					$810,490
End Use					
Booster Pumps	$470,850	$3,400	$33,840		$508,090
Subtotal					$508,090
Groundwater Monitoring	0	6,500	149,500		$156,000
Subtotal					$156,000
TOTAL ANNUAL O&M COST					$1,825,815
PRESENT WORTH OF ANNUAL O&M COST					$28,067,252
TOTAL PRESENT WORTH					$39,658,455

Table 13-15

ESTIMATED COST - ALTERNATIVE 4: NORTH PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST								
Groundwater Extraction								
Extraction Wells	500	lf	$60	$140	$200	$30,000	$70,000	$100,000
Extraction Pumps	1	ea	36,000	9,000	45,000	36,000	9,000	45,000
Pipeline	2,500	lf	36	44	80	90,000	110,000	200,000
Subtotal								$345,000
Treatment Facilities								
Temporary Filters	3	ea	$10,000	$1,200	$11,200	$30,000	$3,600	$33,600
Ozone Generators	3	ea	312,000	35,000	347,000	936,000	105,000	1,041,000
Air Preparation Units	3	ea	52,000	6,000	58,000	156,000	18,000	174,000
Off-gas Destruction Units	2	ea	9,100	3,200	12,300	18,200	6,400	24,600
Peroxide Feed System	1	ls	46,000	11,000	57,000	46,000	11,000	57,000
Treatment Tankage	1	ls	132,000	45,000	177,000	132,000	45,000	177,000
Effluent Tank	1	ls	51,300	24,700	76,000	51,300	24,700	76,000
Chlorination System	1	ls	30,700	5,000	35,700	30,700	5,000	35,700
Building	3,800	sf	50	20	70	190,000	76,000	266,000
Controls & Instrumentation	1	ls	95,449	40,907	136,356	95,449	40,907	136,356
Structural	1	ls			37,950			37,950
Site Work & Yard Piping		ls			205,921			205,921

Table 13-15 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 4: NORTH PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total
CAPITAL COST (Cont'd.)								
Site Electrical		ls			$185,427			$185,427
Subtotal								$2,450,554
End Use								
Booster Pumps	3	ea	$68,800	$34,000	$102,800	$206,400	$102,000	$308,400
Subtotal								308,400
Groundwater Monitoring Wells								
Wells	1,800	lf	$35	$80	$115	$63,000	$144,000	207,000
Well Head Completion	3	ea	6,000	3,000	9,000	18,000	9,000	27,000
Subtotal								234,000
TOTAL CONSTRUCTION COST								3,337,954
Contractor OH & P		15%						500,693
Engineering & Const. Management		15%						500,693
Administration		5%						166,898
Contingency		20%						667,591
TOTAL CAPITAL COST								5,173,829

Table 13-15 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 4: NORTH PLANT

Description	Utilities	Materials	Labor	Total
ANNUAL O&M COST				
Groundwater Extraction				
Extraction Wells	$329,600	$2,400	$18,000	$350,000
Pipeline	0	2,500	1,800	$4,300
Subtotal				$354,300
Treatment Facilities				
Ozone Generation	$250,750	$25,000	$31,200	$306,950
Peroxide System	4,540	73,600	16,000	94,140
Chlorination System	1,470	6,220	16,000	23,690
Subtotal				$424,780
End Use				
Booster Pumps	$235,400	$1,880	$28,300	$265,580
Subtotal				$265,580
Groundwater Monitoring	$0	$500	$7,500	8,000
Subtotal				8,000
TOTAL ANNUAL O&M COST				$1,052,660
PRESENT WORTH OF ANNUAL O&M COST				$16,181,964
TOTAL PRESENT WORTH				$21,355,793

13.2.5 Alternative 5: Aqueous GAC with Reinjection

This alternative uses groundwater extraction wells placed ahead of the leading edge of the plume and within the plume near the existing Newmark Treatment Plant. The extracted groundwater would be transmitted through buried piping to the GAC treatment plant. The treated water is then reinjected into the groundwater aquifer downgradient from the extraction wells. Design criteria for this alternative are presented in Table 13-16.

Groundwater Extraction

Groundwater extraction process is the same as in Alternative 2 and consists of four 2,000 gpm wells ahead of the plume and one new 800 gpm well in Newmark. The water collection and transmission system and the proposed treatment plant sites are also the same as Alternative 2.

Treatment System

The proposed South Treatment Plant is shown on Figure 13-18 and the North Treatment Plant is as shown on Figure 13-13. The North Treatment Plant in Alternative 5 is same as that of North Treatment Plant in Alternative 2.

GAC Treatment. The GAC treatment process is the same as for Alternative 2. Raw water is treated by pairs of GAC units. Each pair operates in series with a lead and a lag treatment vessel. The plant is composed of multiple pairs operating in parallel.

Effluent System. Treated water from the lag vessel discharges into a common header that conveys the water to the return transmission pipe line. Pressure, provided by the extraction well pumps, is maintained throughout the closed system.

Table 13-16

DESIGN CRITERIA
ALTERNATIVE 5

Item	Units	South Plant	North Plant
GROUNDWATER EXTRACTION SYSTEM			
1. Extraction Wells			4 existing
Number	each	4	1 additional
Capacity (each)	gpm	2,000	800
Total Capacity	gpm	8,000	4,000
Estimated Well Depth	ft	1,100	500
Approximate Depth to Groundwater	ft	100	230
Casing Diameter	inch	20	16
Total Pumping Head	ft	152	350
2. Raw Water Transmission System			
30-inch Diameter	L.F.	12,000	--
24-inch Diameter	L.F.	1,200	--
16-inch Diameter	L.F.	1,200	--
12-inch Diameter	L.F.	--	2,500
TREATMENT SYSTEM			
1. Plant Capacity	gpm	8,000	4,000
	MGD	11.5	5.8
Influent Concentration			
Tetrachloroethylene (PCE)	μg/L	75	75
Trichloroethylene (TCE)	μg/L	10	10
Effluent Concentration			
Tetrachloroethylene (PCE)	μg/L	2	2
Trichloroethylene (TCE)	μg/L	2	2
2. Treatment			
Type: Granular Activated Carbon			
Number of Units	pairs	8	4
Unit Operation	--	series	series
Plant Operation		parallel	parallel
Flow Per Unit	gpm	1,000	1,000
Total Vessels	each	16	8
Carbon Volume (each)	ft^3	715	715
Carbon Volume (each pair)	ft^3	1,430	1,430
Empty Bed Contact Time (EBCT)(each	min	5.3	5.3
vessel)	min	10.7	10.7
EBCT (per pair)			
EBCT (one pair offline)	min	4.7	4.0
Each Vessel	min	9.4	8.0
Per Pair	lb	20,000	20,000
Carbon Per Vessel	lb	320,000	160,000
Total Plant Carbon	days	292	292
Estimated Carbon Life (per vessel)	lb	400,000	200,000
Estimated Annual Usage	psi	125	125
ASME Vessel & Pressure Rating			

Table 13-16 (Cont'd.)

DESIGN CRITERIA
ALTERNATIVE 5

Item	Units	South Plant	North Plant
3. Disinfection			
Type: Gaseous Chlorine			
Dosage Rate	mg/L	0.5 - 1.0	0.5 - 1.0
	lb/day	48 - 96	24 - 48
Residual	mg/L	0.3 - 0.5	0.3 - 0.5
Unit Size	lb/day	200	100
Control	--	continuous	continuous
Storage Cylinder Size	lb	2,000	2,000
Number of Cylinders	each	4	4
4. Backwash System			
Rate	gpm	1,200	1,200
Nominal Time	min	15	15
Tank Size (Diameter x Height)	ft	26 x 8	26 x 8
Tank Working Capacity	gal (1000)	28	28
Tank Seismic Construction	--	anchored	anchored
5. Start Up Filtration			
Type: Bag Filters			
Number of Vessels	each	5	3
Flow per Vessel	gpm	2,000	2,000
Bags per Vessel	each	10	10
<u>END USE</u>			
1. Injection Wells			Not Applicable
Number	each	4	
Capacity (each)	gpm	2,000	
Total Capacity	gpm	8,000	
Estimated Well Depth	ft	1,100	
Approximate Depth to Groundwater	ft	100	
Casing Diameter	inch	20	
2. Finished Water Transmission System			Not Applicable
30-inch Diameter	ft	3,400	
24-inch Diameter	ft	6,000	
16-inch Diameter	ft	6,300	
3. Municipal System			
Number of Pumps: Vertical Turbine	each	Not applicable	3
Total Pumping Rate	gpm		4,000
Pump Rate (each)	gpm		2,000

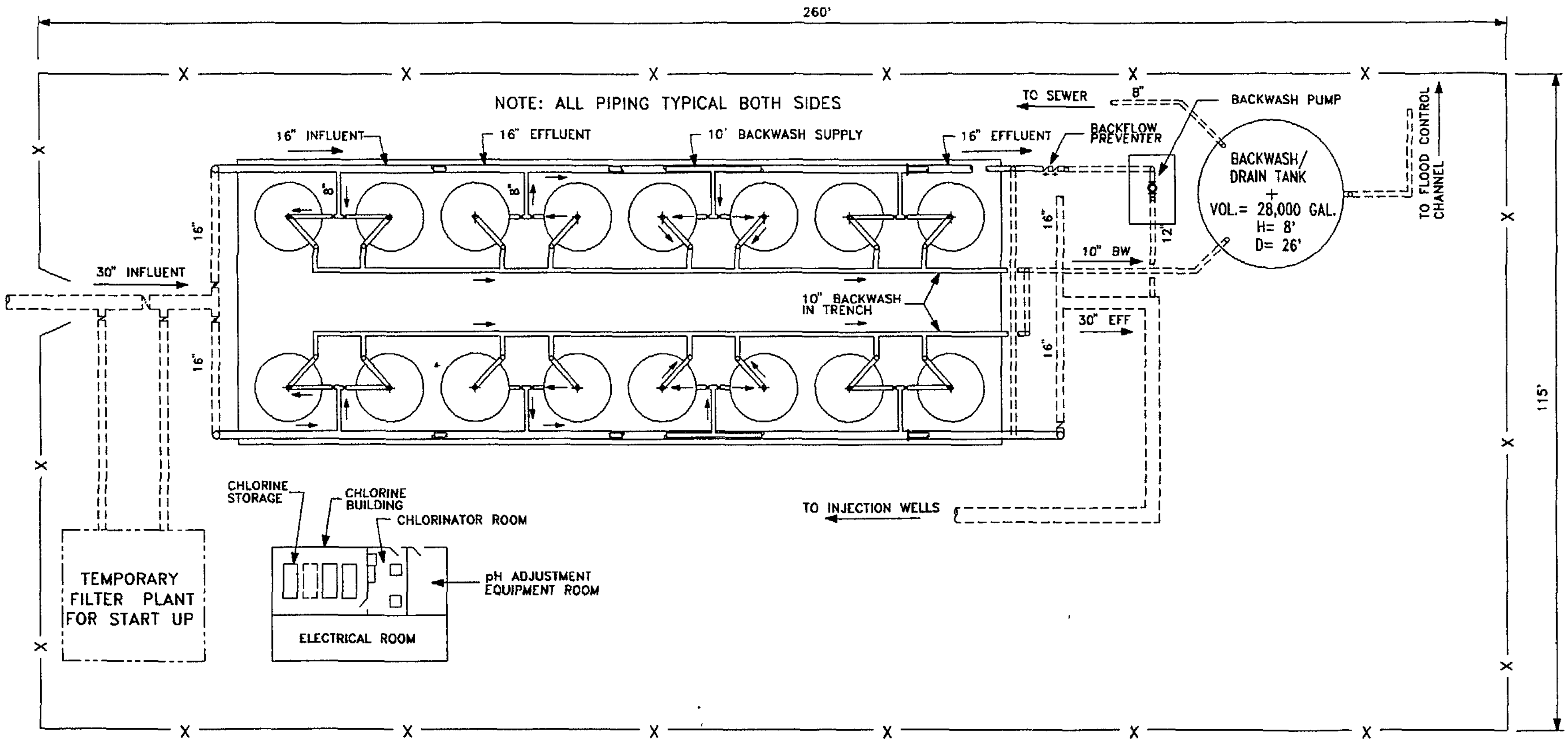


FIGURE 13-18
ALTERNATIVE 5
AQUEOUS GAC WITH REINJECTION
SOUTH PLANT

Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report

ARCS EPA REGIONS IX & X WA NO 54-10-9LJ5

URS CONSULTANTS
2710 GATEWAY OAKS DR.
SUITE 250 NORTH
SACRAMENTO, CA 95834
(916) 929-2346

Backwash System. The backwash system for this alternative is the same as for Alternative 2, except that wash water is obtained directly from the plant effluent pipe. The GAC vessels backwash using piping and valving contained within the skid mounted units. Wash water flows to the backwash holding tank where it is discharged to the sanitary sewer.

Start-Up Filtration. The operation of the pre-filtration plant will be the same as Alternative 2. The bag filters will operate during plant start-up and well development.

End Use

This alternative will re-inject the treated water from the South Treatment Plant back into the groundwater aquifer. Six injection wells, with a total capacity of 8,000 gpm each would be located down gradient of the extraction wells approximately as shown on Figure 13-19. The wells would be drilled to an approximate depth of 1,100 feet and water would be injected into the two aquifers. Injecting the water at this location would create a hydraulic mound in the aquifer. This mound would provide greater hydraulic control of the aquifer by increasing the hydraulic gradient toward the extraction wells. Water would be conveyed to the injection wells via a transmission pipeline from the treatment plant. Injection pressure would come from the extraction well pumps by maintaining a closed, pressurized system through the treatment plant and pipe lines. Figure 13-19 also shows the proposed pipeline alignment.

The end use of the water processed by the North Treatment Plant would be the same as Alternative 2. Water would be supplied to the municipal pump station.

Groundwater Monitoring Wells

The groundwater monitoring wells in this alternative are the same as those discussed in Alternative 2. Four monitoring wells would be installed downgradient of extraction wells in the plume front area. The depth of these wells is 1,200 feet. Also, three additional monitoring wells with a depth of 600 feet would be installed downgradient of Newmark Wellfield.

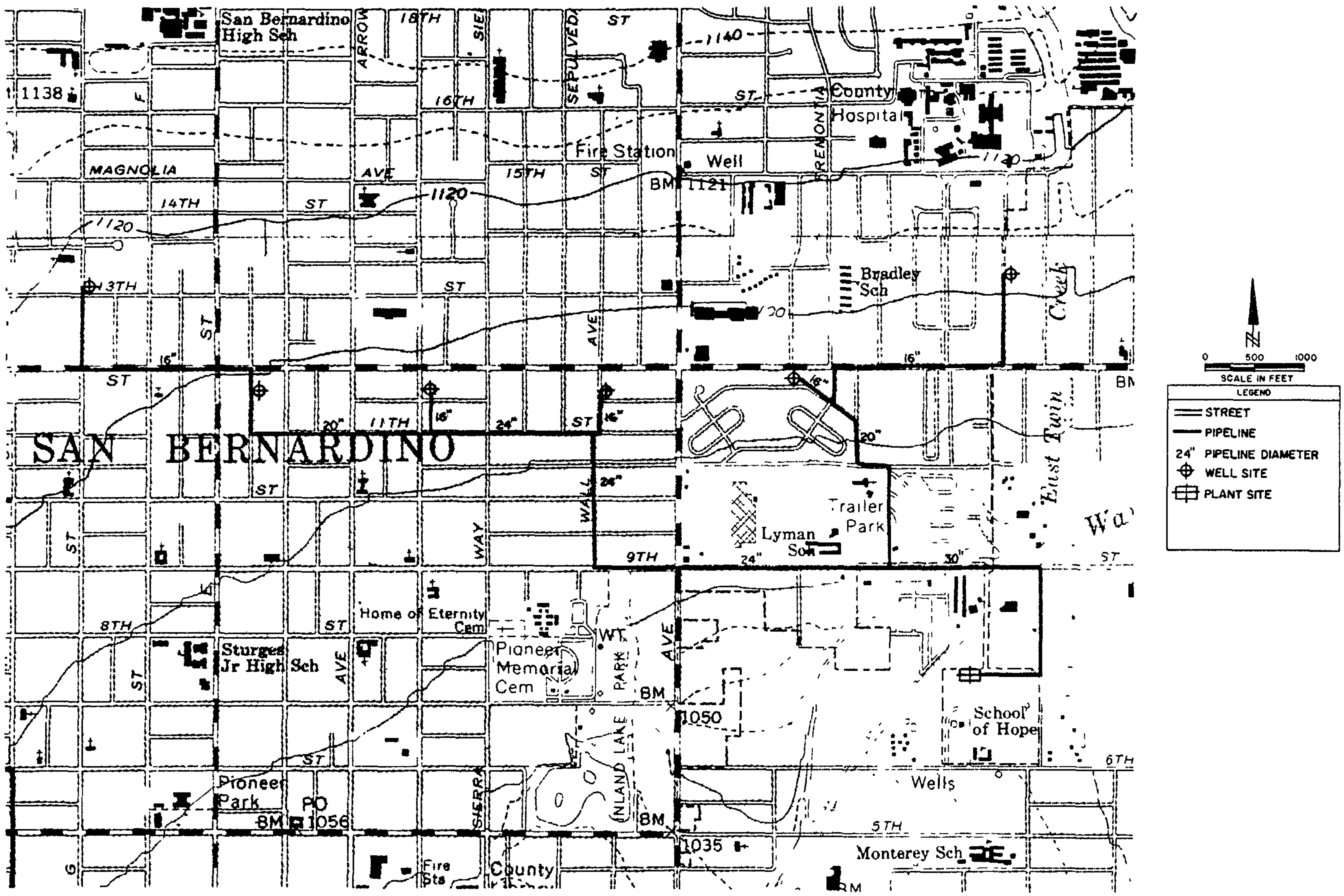


FIGURE 13-19

ALTERNATIVE 5
SOUTH PLANT
INJECTION WELL LOCATION
& PIPELINE ROUTE

Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report

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Overall Protection of Human Health and the Environment - The aqueous GAC with reinjection alternative would protect human health and the environment.

Similar to the discussion of Alternative 2, this alternative is a treatment control which utilizes carbon adsorption to capture contaminants from groundwater. Off-site regeneration serves to destroy contaminants to eliminate potential risks to human health and to the environment.

Contamination levels are reduced to drinking water standards prior to injection, thereby increasing protection.

Compliance with ARARs - This alternative meets the CERCLA/SARA preference for treatment prior to off-site disposal to permanently reduce contaminant toxicity, mobility, or volume.

This evaluation is similar to that of Alternative 2 in transportation standards applicable to generators of hazardous waste under RCRA. Federal and State DOT regulations governing transportation of hazardous waste will be observed during transportation of spent carbon.

The regeneration facility accepting spent carbon is required to be in compliance with, and also expected to meet, applicable federal and State permit requirements relevant to hazardous waste disposal facilities.

Long-Term Effectiveness and Permanence - The aqueous GAC with reinjection alternative would provide long-term effectiveness.

As discussed in the evaluation of Alternative 2, the magnitude of residual risk is low. The alternative is adequate and suitable to treat the volume of groundwater expected to be encountered at Newmark. It is a proven and reliable method to treat groundwater that does not result in untreated wastes remaining on site.

Also, as previously discussed, exposure is limited to human and environmental receptors while carbon is being exchanged. The potential need to replace the alternative or components of the alternative is low.

Reduction of Toxicity, Mobility, or Volume - This alternative permanently and irreversibly reduces contaminant toxicity, mobility, and volume through carbon adsorption and regeneration. It is expected to reduce levels of contamination to meet Remedial Action Objectives. Treatment cannot be reversed because contaminants are destroyed off site during regeneration. Only adsorbed VOC residuals would remain after remediation.

Short-Term Effectiveness - The aqueous GAC with reinjection alternative would provide short-term effectiveness.

Similar to the discussion of Alternative 2, potential health threats to area residents or the environment are not expected, during construction and implementation. Personnel responsible for spent carbon handling would need to have proper personal protective equipment.

Implementability - The aqueous GAC with reinjection alternative would be implementable.

Similar to the discussion of Alternative 2, the technologies are demonstrated and commercially available, and significant technical unknowns are not expected, during construction and operation.

This alternative is considered to be reliable to operate and maintain during implementation, and additional remedial actions are not expected to be difficult to implement. Monitoring the alternative is considered to be easily accomplished at the extraction wells, GAC unit, and regeneration facility.

Administrative feasibility is similar to that of Alternative 2, with permits for on-site treatment and off-site spent carbon transport being required. The exception to the similarity is approval for treated water disposal using injection wells is required.

Availability of regeneration facilities, necessary equipment, and personnel is high.

Cost - Table 13-17 presents the costs associated with the South Treatment Plant and Table 13-9 presents the North Treatment Plant costs. Note that the cost estimate for North Plant in Alternative 5 is same as that of North Treatment Plant in Alternative 2. The total project cost for this alternative is obtained by adding the cost of North and South Treatment Plants. The total project cost for Alternative 5 (capital cost - approximately $16.3 million, annual O&M cost - approximately $2.1 million, and total present worth - approximately $48.1 million) is presented in Table 13-5.

13.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The purpose of this comparative analysis is to identify the relative advantages and disadvantages of each alternative. Areas of potential tradeoffs, such as one alternative being well-demonstrated, whereas another may be innovative but less proven, are also identified.

Overall Protection of Human Health and the Environment, and Compliance with ARARs are considered threshold criteria and must be satisfied for an alternative to be implemented. The present worth cost is presented so an independent evaluation by the EPA can be based on actual cost and not the ranking system. State and Community Acceptance will be considered after comments are received on the Proposed Plan.

The remaining criteria are evaluated for each alternative. Each alternative is assigned a ranking number from one to five. A one represents a low ranking and five is a high ranking. The numerical total of the criteria scores presents the relative ranking of alternatives.

Table 13-18 summarizes the ranking results of this comparison.

Table 13-17

ESTIMATED COST - ALTERNATIVE 5: SOUTH TREATMENT PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST (Cont'd.)								
Groundwater Extraction								
Extraction Wells	$4,400	ea	$60	$140	$200	$264,000	$616,000	$880,000
Extraction Pumps	4	ea	46,000	9,000	55,000	184,000	36,000	220,000
Pipeline	14,400	lf	50	58	108	720,000	835,200	1,555,200
Subtotal								2,435,200
Treatment Facilities								
Temporary Filters	5	ea	$10,000	$1,200	$11,200	$50,000	$6,000	$56,000
GAC Units	8	pairs	186,000	5,600	191,600	1,488,000	44,800	1,532,800
Backwash Tank	1	ea	27,000	8,000	35,000	27,000	8,000	35,000
Backwash Pump	1	ea	18,000	6,000	24,000	18,000	6,000	24,000
Chlorination System	1	ls	43,000	7,000	50,000	43,000	7,000	50,000
pH Control System	1	ls	43,000	7,000	50,000	43,000	7,000	50,000
Building	640	sf	50	20	70	32,000	12,800	44,800
Structural	1	ls			162,380			162,380
Site Work & Yard Piping		ls			195,498			195,498
Site Electrical		ls			37,840			37,840
Subtotal								2,188,318

Table 13-17 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 5: SOUTH TREATMENT PLANT

Description	Quantity	Unit	Unit Cost Material	Unit Cost Labor	Unit Cost Total	Total Cost Material	Total Cost Labor	Total Cost Total
CAPITAL COST (Cont'd.)								
End Use								
Injection Well	6,600	lf	$60	$140	$200	$396,000	$924,000	$1,320,000
Pipeline	20,150	lf	42	48	90	846,300	967,200	1,813,500
Subtotal								3,133,500
Groundwater Monitoring Wells								
Wells	4800	lf	$40	$95	$135	$192,000	$456,000	$648,000
Well Head Completion	4	ea	6,000	3,000	9,000	24,000	12,000	36,000
Subtotal								$684,000
TOTAL CONSTRUCTION COST								8,441,018
Contractor OH & P		15%						1,266,153
Engineering & Const. Management		15%						1,266,153
Administration		5%						422,051
Contingency		20%						1,688,204
TOTAL CAPITAL COST								13,083,579

Table 13-17 (Cont'd.)

ESTIMATED COST - ALTERNATIVE 5: SOUTH TREATMENT PLANT

Description	Utilities	Materials	Labor	Total
ANNUAL O&M COST				
Groundwater Extraction				
Extraction Wells	$282,500	$4,875	$34,500	$321,875
Pipeline	0	20,000	9,360	29,360
Subtotal				351,235
Treatment Facilities				
GAC Units	$0	$400,000	$27,000	$427,000
Backwash Pumps	880	2,440	5,150	8,470
Chlorination System	2,270	9,720	18,000	29,990
pH System	6,880	38,880	18,000	63,760
Subtotal				$529,220
End Use				
Injection Well	$0	$5,000	$31,170	$36,170
Pipeline	0	20,000	9,360	29,360
Subtotal				$65,530
Groundwater Monitoring Wells	$0	$6,500	$149,500	$156,000
Subtotal				$156,000
TOTAL ANNUAL O&M COST				$1,101,985
PRESENT WORTH OF ANNUAL O&M COST				$16,940,210
TOTAL PRESENT WORTH				30,023,789

Table 13-18

ALTERNATIVE COMPARATIVE ANALYSIS
Newmark Site

Remedial Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume	Short-Term Effectiveness	Implementability	Approximate Cost	Total Score	Ranking
Alternative 1: No Action	No	No	1	1	5	3	$3.5 million	10	5
Alternative 2: Aqueous Phase GAC	Yes	Yes	4	4	4	4	$49.9 million	16	3
Alternative 3: Air Stripping with Off-Gas Treatment	Yes	Yes	4	3	4	3	$47.9 million	14	1
Alternative 4: Advanced Oxidation	Yes	Yes	4	5	3	2	$61.0 million	14	2
Alternative 5: Aqueous Phase GAC with Injection Well	Yes	Yes	4	4	4	4	$48.1 million	16	4

Notes:
a. State and community acceptance criteria are not compared.
b. Yes = Meets the criteria.
c. No = Does not meet the criteria.
d. High ranking number = The alternative that comparatively best meets the criteria.
e. Low ranking number = The alternative that comparatively least meets the criteria.
f. N/A = Not Applicable

13.3.1 Overall Protection of Human Health and the Environment

All of the alternatives except Alternative 1, No Action, are protective of human health and the environment. They meet the Remedial Action Objectives to prevent ingestion of TCE and PCE above the MCLs of 5 ppb. Also, each of these alternatives would restore the quality of the aquifer by reducing contaminant levels to below the MCL. The No Action alternative does not reduce risk of exposure or restore quality of the aquifer.

13.3.2 Compliance with ARARs

All alternatives except Alternative 1, No Action, meet preliminary ARARs set by the EPA as discussed in Subsection 13.3.1.

13.3.3 Long-Term Effectiveness and Permanence

All treatment alternatives were given a ranking of 4 because they all provide the same level of residual risk and reliability of treatment after the remedial action is complete.

The No Action alternative were given a ranking of 1 because it does not provide long-term effectiveness.

13.3.4 Reduction of Toxicity, Mobility, or Volume

All of the alternatives except Alternative 1, No Action, provide a high degree of reduction in toxicity, mobility, or volume. Alternative 4, Advanced Oxidation with Municipal End Use, was given the highest ranking of 5 because this treatment process is destructive. Alternative 2, Aqueous GAC with Municipal End Use, and Alternative 5, Aqueous GAC with Reinjection, were given a ranking of 4, because carbon regeneration is required. Alternative 3, Air Stripping with Vapor Phase Off-gas GAC and Municipal End

Use, was given a slightly lower ranking of 3 because low levels of contaminants will be emitted from the off-gas treatment system. The No Action alternative was given a ranking of 1 because it does not reduce toxicity, mobility, or volume.

13.3.5 Short-Term Effectiveness

Alternative 1, No Action, was given the highest ranking of 5 because it has the smallest risk of exposure of workers to contamination during implementation. The alternatives that use some form of GAC, Alternatives 2, 3, and 5, were given a ranking of 4 because of the slight risk of exposure when spent carbon is transported to a regeneration and disposal facility. Workers may also be exposed during this process. Alternative 4, Advanced Oxidation, was given a ranking of 3 because of the risk of exposure to oxidants during operation of the treatment plant.

13.3.6 Implementability

Alternative 1, No Action, was given a ranking of 3 because it is easily implemented both technically and administratively. Services and equipment are readily available for monitoring.

Alternatives 2 and 5 which use aqueous GAC were given a slightly higher ranking of 4 because more coordination with agencies will be required to construct the treatment facilities. Air stripping with vapor phase GAC off-gas treatment, Alternative 3, was given a 3 because air discharge permits are required. Services and equipment are readily available for all GAC treatment alternatives.

Alternative 4, Advanced Oxidation, was given a ranking of 2 because the process has not been widely used for VOC treatment. Because advanced oxidation has been used in the waste-water industry equipment and services can be easily obtained.

13.3.7 Cost

This section compares the costs, then presents cost sensitivity analysis for the alternatives.

Cost Comparison

A feasibility cost comparison criterion is based on the total present worth of each alternative. Present worth analysis provides a method of evaluating and comparing costs that occur over a time period by discounting all future expenditures to the present year. The total present worth of each alternative is calculated using capital cost, annual O&M cost, duration (or lifetime) of the project, and a discount rate. Detail of present worth calculations is presented in Section 13.2.

Table 13-19 summarizes capital cost, annual O&M cost, and total present worth for the South Plant, the North Plant and the Total Project (Total Project costs are obtained by adding the cost of South and North Plants) for all alternatives. Figures 13-20 and 13-21 show the comparison of capital cost and annual O&M cost for the South Plant, the North Plant and the Total Project. Similarly, Figure 13-22 shows the comparison of total present worth of the Total Project for all alternatives.

Alternative 2 and Alternative 5 are identical except the end use at the South Plant is changed to injection wells. Because of this difference in end use, capital cost for the South Plant in Alternative 5 is larger than that for the South Plant of Alternative 2. Despite the difference in capital cost, the Total Present Worth of Alternative 2 and Alternative 5 are within comparable range. This can be attributed to higher annual O&M cost involved in Alternative 2.

The capital cost of Alternative 1 is the least as it includes construction of four monitoring wells. The capital costs of Alternatives 4 and 5 are almost the same. Among the alternatives that include treatment systems, the capital cost of Alternative 3 is the cheapest, and the capital cost of Alternatives 4 and 5 are the highest.

The total present worth of Total Project in Table 13-19 shows that Alternative 1 is the least expensive because of its small capital and annual O&M costs. Alternative 4 is the most expensive because of its higher capital cost and annual O&M cost. The Total Project cost for Alternative 3 (approximately $47.9 million) and Alternative 5 (approximately $48.1 million) are approximately the same, and the Total Project cost for Alternative 2 is approximately $2.0 million higher than Alternative 3 and 5.

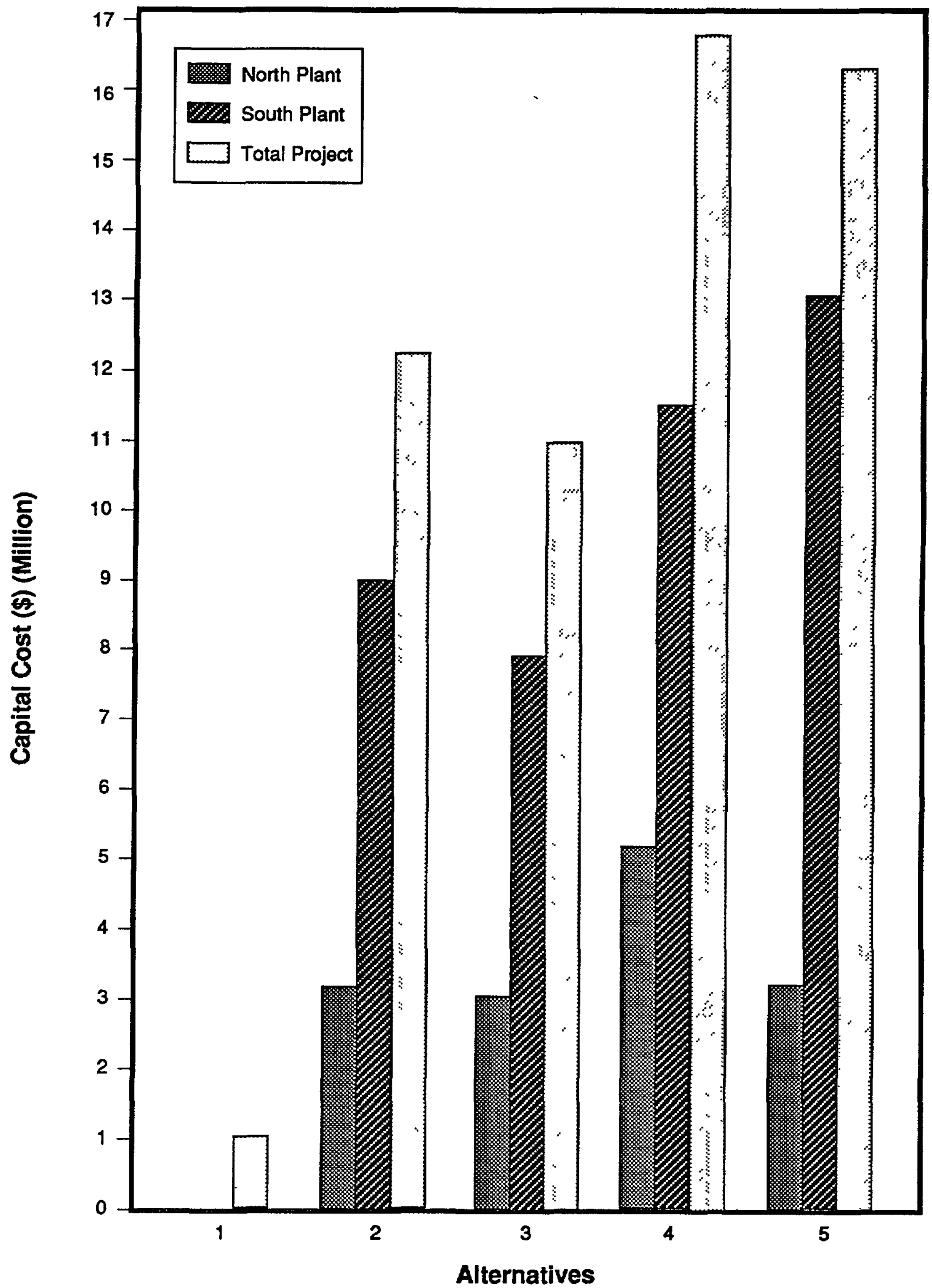

Figure 13-20
Comparison of Capital Cost
Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report

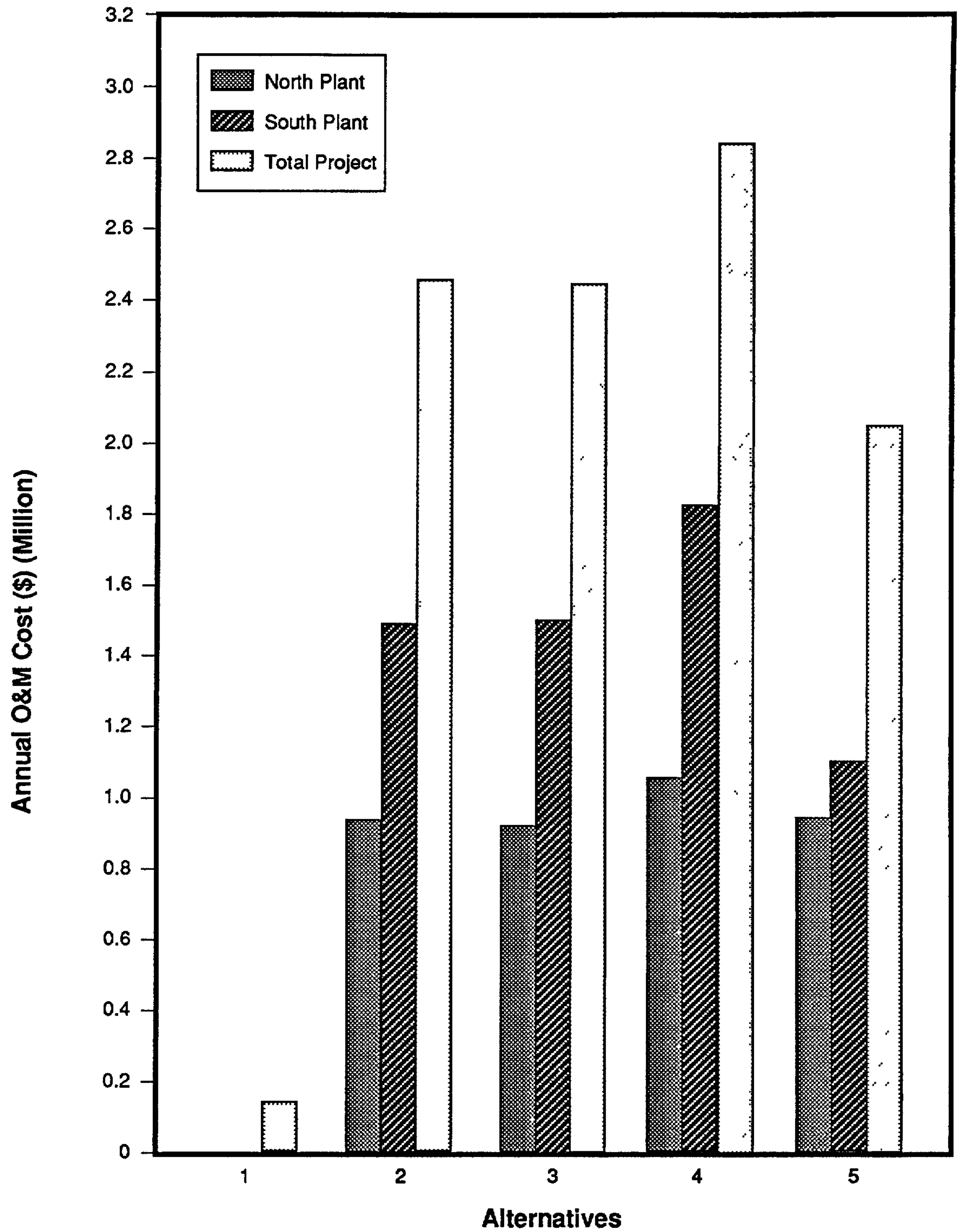

Figure 13-21
Comparison of Annual O&M Cost
Newmark Groundwater Superfund
Newmark Operable Unit RI/FS Report

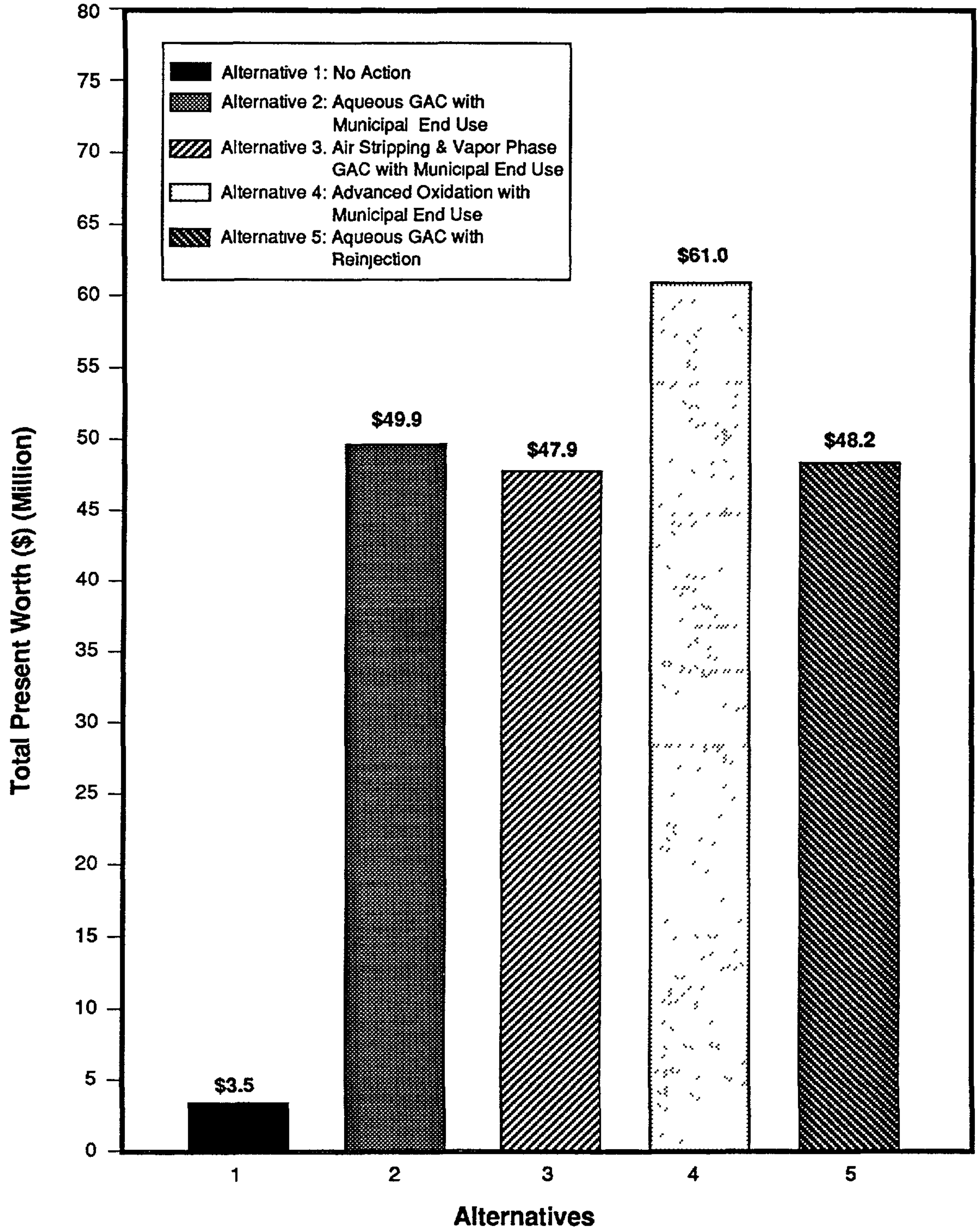

Figure 13-22
Comparison of Present-Worth of Alternatives
Newmark Groundwater Superfund Site
Newmark Operable Unit RI/FS Report

Table 13-19

COMPARISON OF COST FOR THE ALTERNATIVES

		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
South Plant	Capital Cost ($)	N/A	9,005,921	7,951,839	11,591,203	13,083,579
	Annual O&M Cost ($)		1,480,785	1,487,515	1,825,815	1,101,985
	Total Present Worth ($)		31,769,216	30,818,590	39,658,455	30,023,789
North Plant	Capital Cost ($)	N/A	3,250,456	3,054,282	5,173,829	3,250,456
	Annual O&M Cost ($)		967,630	912,275	1,052,660	967,630
	Total Present Worth ($)		18,125,301	17,078,185	21,355,793	18,125,301
Total Project	Capital Cost ($)	1,060,200	12,256,377	11,006,121	16,765,032	16,334,035
	Annual O&M Cost ($)	156,000	2,448,415	2,399,790	2,878,675	2,069,615
	Total Present Worth ($)	3,458,302	49,894,517	47,896,775	61,014,248	48,149,090

Note: Summation of South Plant and North Plant cost gives the cost for Total Project.
NA: Not Applicable

Sensitivity Analysis

Cost sensitivity analysis for the alternatives is presented in this subsection. The sensitivity analysis assesses the effect of varying key assumptions or factors associated with the cost estimate. Assumptions or factors that can significantly affect the present worth of the alternatives are considered for the sensitivity analysis. The sensitivity of cost associated with alternatives can be evaluated by varying those key factors and calculating the corresponding variation on the estimated cost.

The following factors are considered for the sensitivity analysis: annual aqueous carbon usage for Alternatives 2 and 5, air/water ratio for Alternative 3, and ozone/peroxide dosage rate for Alternative 4. These factors, as seen in the Estimated Cost tables presented in Section 13.2, can significantly affect the total present worth of the alternatives. Influent water concentration is another factor that can affect the present worth significantly. Details of the cost sensitivity analysis for each alternative are presented below.

Factors involved (number of monitoring wells, frequency of sampling and number of wells to be installed) in the cost estimate for Alternative 1 represent a fairly definite set of assumptions. Thus, a sensitivity analysis for this alternative is not necessary.

Sensitivity analysis for Alternative 2 was performed by varying the annual aqueous carbon usage. Table 13-20 shows the results of the sensitivity analysis for Alternative 2. Sensitivity analysis was performed for South Plant, North Plant, and the Total Project (total project cost is obtained by adding the cost for both South and North Plants). Three different values for annual carbon usage (Low, Design, and High) were used for the sensitivity analysis. The carbon usage design value, as presented in Table 13-7, was determined using the isotherm calculation and vendor's quotation for influent water concentration of 75 ppb PCE and 10 ppb TCE. Low and high values include the range of carbon usage proposed by various vendors. The sensitivity analysis shown in Table 13-20 indicates that the present worth for Alternative 2 can decrease or increase by approximately \$3.7 million when the annual carbon usage is varied from the low to high value.

Table 13-20

SENSITIVITY ANALYSIS: VARIATION OF ANNUAL CARBON USAGE - ALTERNATIVE 2

	Annual Carbon Usage (x 1000 lb)		Capital Cost	Annual O&M	Present Worth	Total Present Worth
South Plant	Low	250	$9,005,921	$1,320,660	$20,301,781	$29,307,702
	Design	400	$9,005,921	$1,480,785	$22,763,295	$31,769,216
	High	550	$9,005,921	$1,640,910	$25,224,809	$34,230,730
North Plant	Low	125	$3,250,456	$887,005	$13,635,441	$16,885,897
	Design	200	$3,250,456	$967,630	$14,874,845	$18,125,301
	High	275	$3,250,456	$1,048,255	$16,114,249	$19,364,705
Total Project	Low	375	$12,256,377	$2,207,665	$33,937,222	$46,193,599
	Design	600	$12,256,377	$2,448,415	$37,638,140	$49,894,517
	High	825	$12,256,377	$2,689,165	$41,339,058	$53,595,435

Notes: Total Project row represents the cost for this Alternative. Total Project Costs are obtained by adding the costs for South Plant and North Plant.

Present Worth column shows the present worth of annual O&M cost calculated for a duration of 30 years with a discount rate of 5%.

Total Project Worth column is obtained by adding Capital Cost column and Present Worth column.

Air/water ratio required to strip organics from the water was used for the sensitivity analysis for Alternative 3. Table 13-21 shows the results of the sensitivity analysis for South Plant, North Plant and Total Project (summation of South and North Plants) for this alternative. The three different values for air/water ratio (Low = 10, Design = 22, and High = 30) were based on the vendor's quotation. The sensitivity analysis indicates that the present worth for Alternative 3 can decrease by approximately $2.7 million or increase by approximately $1.8 million when the air/water ratio is varied from the low to high.

Ozone/peroxide dosage rate was used for the sensitivity analysis for Alternative 4. Table 13-22 shows the results of sensitivity analysis for South Plant, North Plant and Total Project (summation of South and North Plants). The three different values for ozone/peroxide ratio (Low = 6.5:3, Design = 13:6, and High = 18:9) were based on vendor's quotation. The sensitivity analysis indicates that the present worth for Alternative 4 can decrease by approximately $7.6 million or increase by approximately $9.5 million depending on the ozone/peroxide ratio.

Sensitivity analysis for Alternative 5 was performed by varying the annual aqueous carbon usage. Table 13-23 shows the results of sensitivity analysis for South Plant, North Plant and Total Project (summation of South and North Plants) for this alternative. As discussed in the sensitivity analysis for Alternative 2, three different values for annual carbon usage were used for the sensitivity analysis. Note that the sensitivity analysis for North Plant for this Alternative is the same as that of North Plant of Alternative 2. The sensitivity analysis indicates that the present worth for Alternative 5 can decrease or increase by approximately $3.7 million when the annual carbon usage is varied from the low to high value.

Table 13-21

SENSITIVITY ANALYSIS: VARIATION OF AIR/WATER RATIO - ALTERNATIVE 3

	Air/Water Ratio		Capital Cost	Annual O&M	Present Worth	Total Project Worth
South Plant	Low	10	$7,914,269	$1,371,715	$21,086,622	$29,000,891
	Design	22	$7,951,839	$1,487,515	$22,866,751	$30,818,590
	High	30	$7,989,409	$1,564,716	$24,063,520	$32,052,929
North Plant	Low	10	$3,035,783	$854,375	$13,133,835	$16,169,618
	Design	22	$3,054,282	$912,275	$14,023,903	$17,078,185
	High	30	$3,072,782	$950,875	$14,617,279	$17,690,061
Total Project	Low	10	$10,950,052	$2,226,090	$34,220,457	$45,170,509
	Design	22	$11,006,121	$2,399,790	$36,890,654	$47,896,775
	High	30	$11,062,191	$2,515,591	$38,670,799	$49,732,990

Notes: Total Project row represents the cost for this Alternative. Total Project Costs are obtained by adding the costs for South Plant and North Plant.

Present Worth column shows the present worth of annual O&M cost calculated for a duration of 30 years with a discount rate of 5%.

Total Project Worth column is obtained by adding Capital Cost column and Present Worth column.

Table 13-22

SENSITIVITY ANALYSIS: VARIATION OF DOSAGE RATE - ALTERNATIVE 4

	Ozone Peroxide (O_3) (H_2O_2)			Capital Cost	Annual O&M	Present Worth	Total Present Worth
South Plant	Low	6.5	3	$10,205,226	$1,501,465	$23,081,197	$33,286,423
	Design	13	6	$11,591,203	$1,825,815	$28,067,252	$39,658,455
	High	18	9	$12,906,170	$2,150,166	$33,053,306	$45,959,476
North Plant	Low	6.5	3	$4,421,667	$890,485	$13,688,937	$18,110,604
	Design	13	6	$5,173,829	$1,052,660	$16,181,964	$21,355,793
	High	18	9	$5,854,355	$1,214,835	$18,674,992	$24,529,347
Total Project	Low	6.5	3	$14,626,893	$2,391,950	$38,770,134	$53,397,027
	Design	13	6	$16,765,032	$2,878,475	$44,249,216	$61,014,248
	High	18	9	$18,760,525	$3,385,000	$51,728,298	$70,488,823

Notes: Total Project row represents the cost for this Alternative. Total Project Costs are obtained by adding the costs for South Plant and North Plant.

Present Worth column shows the present worth of annual O&M cost calculated for a duration of 30 years with a discount rate of 5%.

Total Project Worth column is obtained by adding Capital Cost column and Present Worth column.

Table 13-23

SENSITIVITY ANALYSIS: VARIATION OF ANNUAL CARBON USAGE - ALTERNATIVE 5

	Annual Carbon Usage (x 1000 lb)		Capital Cost	Annual O&M	Present Worth	Total Present Worth
South Plant	Low	250	$13,083,579	$941,860	$14,478,697	$27,562,276
	Design	400	$13,083,579	$1,101,985	$16,940,210	$30,023,789
	High	550	$13,083,579	$1,262,110	$19,401,724	$32,485,303
North Plant	Low	125	$3,250,456	$887,005	$13,635,441	$16,885,897
	Design	200	$3,250,456	$967,630	$14,874,845	$18,125,301
	High	275	$3,250,456	$1,048,255	$16,114,249	$19,364,705
Total Project	Low	375	$16,334,035	$1,828,865	$28,114,138	$44,448,173
	Design	600	$16,334,035	$2,069,815	$31,815,055	$48,149,090
	High	825	$16,334,035	$2,310,365	$35,515,973	$51,850,008

Notes: Total Project row represents the cost for this Alternative. Total Project Costs are obtained by adding the costs for South Plant and North Plant.

Present Worth column shows the present worth of annual O&M cost calculated for a duration of 30 years with a discount rate of 5%.

Total Project Worth column is obtained by adding Capital Cost column and Present Worth column.